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SOLENOTHECA, NEW HYOLITHA (MOLLUSCA) FROM THE ORDOVICIAN OF NORTH AMERICA

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Abstract.—The first well-preserved hyoliths from the Ordovician of North America are here described as *Solenotheca bakerae* n. gen., n. sp., family Hyolithidae, order Hyolithida. This species seems to have been a rare component of soft-bottom, normal marine assemblages in Ordovician carbonate rocks, and thus far it appears to be endemic to North America. Poor preservation of the types of the North American Ordovician species *Hyolithes baconi* Whitfield, *H. multicinctus* Bradley, *H. pinniformis* Ruedemann, *H. pumilus* Ruedemann, *H. rhine* Ruedemann, and *H. versaillensis* Miller & Faber renders the generic identification of these species uncertain. *H. baconi* and *H. multicinctus* are included under *Solenotheca* with question; the other species cited above are retained tentatively in *Hyolithes*. Their names should only be used for the type specimens. The holotype of *H.*? *dubia* Miller & Faber is a triobite spine, and this species is here removed from the Hyolitha.

Hyolitha are locally abundant in Cambrian strata of marine origin, but are relatively rare in Ordovician and younger Paleozoic rocks. Cambrian hyoliths in the Soviet Union and China are currently the focus of considerable interest because of their utility in biostratigraphic subdivision of the Lower Cambrian (see Missarzhevsky 1969 and Qian et al. 1985 for detailed list of references). In contrast, except for several recent works (Marek 1967, 1983a, b; Malinky et al. 1987; Houbrick et al. 1988), post-Cambrian Paleozoic hyoliths have been little studied. This report constitutes the first study of North American Ordovician Hyolitha in which modern taxonomic methods are used.

The first hyolith described, *Hyolithes acutus* Eichwald (1840), was from the Ordovician of the eastern European Baltic region. Eichwald (1860) later described several other Ordovician species from that area. The earliest study of the Hyolitha to include detailed consideration of stratigraphic distribution in addition to taxonomy was that of Barrande (1867). Barrande's work was the first monograph ever devoted to hyoliths and other conical problematica, and he included Ordovician as well as younger hyolith species from central Europe. Other Ordovician species from central Europe and Scandinavia were described in later works by Novak (1891), Holm (1893), Reed (1909), and Zazvorka (1928). Thoral (1935) described a fauna of Tremadocian and Arenigian hyolith species from France (Marek 1983b), which included the first known orthothecid hyolith with preserved casts of the intestine and other internal structures (Houbrick et al. 1988). Thoral's specimens served in part as the basis for removing the Hyolitha from the Mollusca and assigning them to the extinct phylum Hyolitha by Runnegar et al. (1975). Marek & Yochelson (1976) continued to regard them as molluscs.

Until recently, species named by those early workers represented nearly one-third of all known Ordovician species. The other Ordovician species were discovered at widely scattered localities throughout the world, and were usually named incidentally

in studies devoted to other organisms or to entire faunas. By the mid-20th century, a total of one hundred eleven Ordovician hyolith species had been named (Sinclair 1946).

Compared to Europe, hyoliths in the Ordovician of North America seem to be quite rare. In nearly a century of study, only nine North American species had been named (Sinclair 1946), and only one occurrence of a previously known European species had been reported (Matthew 1895). None of these species have ever been restudied, and with rare exceptions their names have not been used in the literature for any material except the types. Little is known of their stratigraphic or biogeographic distribution, and nothing of their phylogenetic relationships.

Marek (1963, 1966, 1967, 1983a, b) brought a new perspective to the study of the Hyolitha in general and to Ordovician hyoliths in particular. He reevaluated many of the European species named by Barrande and other early workers, and supplemented the original descriptions with new material from Europe and North Africa. The local abundance of hyoliths in Ordovician carbonate rocks of Baltoscandia was noted by Jaanusson (1984) and Jaanusson & Mutvei (1982) but they did not describe any taxa. With one recent exception (Malinky 1987), no attempt has been made to reevaluate any hyoliths from the Ordovician of North America until now.

Restudy of Ordovician hyoliths from North America indicates that specimens from the Middle Ordovician of the Upper Mississippi Valley region represent *Solenotheca bakerae* n. gen. n. sp., in the family Hyolithidae, order Hyolithida. Morphology of the types of the Ordovician species *Hyolithes baconi* Whitfield (1878) and *H. multicinctus* Bradley (1930) suggests affinity to *Solenotheca,* to which they are here reassigned with question. In contrast, poor preservation of the types of *H. pinniformis* Ruedemann (1912), *H. pumilus* Ruedemann (1926), *H. rhine* Ruedemann (1901), and *H. versaillensis* Miller & Faber (1894) renders the original descriptions of these species inadequate and their generic identifications uncertain; they are retained under *Hyolithes* with question.

The Ordovician hyolith species *Hyolithes vanuexmi* Walcott (1884) from the Eureka district in Nevada was reassigned to *Chelsonella* Malinky (1987), order Orthothecida, class Hyolitha. The type or types of the Ordovician species *H. crowelli* Roy (1941) and *H. parviusculus* (Hall 1862) cannot be located at present. These names should not be used for any other material until the types are located or until well preserved topotypes become available for study. Type specimens of *H.? dubius* Miller & Faber (1894) consist of trilobite spines, and that species is here reassigned to the Arthropoda. The holotype of *H. miseneri* (Foerste, 1917) is presently under study.

Distribution and Paleoecology

Marek's (1976) analyses of the geographic and stratigraphic distribution of fifteen Ordovician hyolith genera was the first and only study of its kind. He recognized two distinct hyolith assemblages in the Ordovician; one occurs in Baltoscandia whereas the other is common in central Europe and North Africa with rare representatives in Australia and South America. None of the genera in these assemblages have been identified unequivocally in North America. However, poor preservation complicates the recognition of any European hyolith taxa in North America. A specimen questionably assigned to the Ordovician genus *Elegantilites* Marek (1967) from Czechoslovakia was reported by Harrison & Harrison (1975) from the Silurian Brassfield Formation in Ohio. A species of the Ordovician genus *Joachimilites* Marek (1967), previously known only in Czechoslovakia has been identified tentatively from the Middle Cambrian Maryville Limestone in Alabama (Malinky 1988). Nonetheless, preliminary

observations support the notion that North American hyoliths comprise a third distinct Ordovician assemblage characterized by *Solenotheca*. Published reports and illustrations of hyoliths from outside North America seem to indicate that *Solenotheca* is endemic to North America. This genus has not been identified yet in any of the well-preserved and relatively abundant Ordovician hyolith assemblages of central Europe or North Africa, or from older hyolith-bearing strata in the Soviet Union and China.

The stratigraphic distribution of *Solenotheca* is poorly known. The types of this genus were collected more than 75 years ago from the Upper Mississippi Valley region by an unknown worker, and geographic and stratigraphic details about those occurrences are not available. The age of *Solenotheca* cannot be determined more precisely than Middle Ordovician (Webers & Austin 1972) because specific localities and associated faunas are not known with certainty. Assignment of *Hyolithes baconi* Whitfield and *H. multicinctus* Bradley to *Solenotheca* does not extend the stratigraphic range of the genus because both of those species were also discovered in the Middle Ordovician. In addition, their inclusion under *Solenotheca* does not extend the geographic range significantly for they also were discovered in the Mississippi Valley region.

Solenotheca has only been reported thus far from carbonate rocks. Middle Ordovician carbonate strata of the Upper Mississippi Valley represent shallow, normal marine environments inhabited by soft-bottom benthic assemblages (Webers 1972). These assemblages are dominated by brachiopods, bryozoans and molluscs; hyoliths seem to have a sporadic distribution in these rocks and are rare at any given locality. Direct examination of type specimens and published accounts in the literature show that most other Ordovician hyoliths in North America occur in carbonates, although a few specimens are known from shale. This may be largely a bias of collection and preservation. Hyoliths in shale and other clastic rocks tend to preserve less well than limestone specimens and may have been overlooked or simply not collected because of preservation.

Fisher (1962) noted that hyoliths occur in a wide range of facies in the marine environment except for hypersaline and reef facies. His observations seem to be based primarily upon Cambrian occurrences. Material described herein and undescribed specimens in collections of the Smithsonian Institution suggest that Ordovician hyoliths were widely distributed geographically and in a variety of marine facies, but were rare overall within the marine environment. To date, assemblages of hundreds of individuals on bedding surfaces in sandstone or more rarely in limestone have not been observed in the Ordovician. Such occurrences are locally known in Cambrian sandstones of the Upper Mississippi Valley (Marek & Yochelson 1976) and in Cambrian limestones of west-central Montana. The relative scarcity of hyoliths in Ordovician and younger Paleozoic rocks may be related to their apparent mechanical inefficiency in comparison to gastropods or other more mobile benthos (Yochelson 1984).

Mode of life of the Hyolitha has been a matter of controversy until recently. Fisher (1962) suggested several possibilities, including benthic with venter down, benthic with the apex embedded in sediment, and nektic and planktic. Marek & Galle (1976) used the presence of an encrusting tabulate coral on the dorsum only of several Devonian hyoliths from central Europe to suggest that a benthic mode of life with venter resting upon the seafloor seemed most likely. Several Late Ordovician specimens from southwestern Ohio (USNM 50107A, USNM 50102A) lend support to their interpretation. These specimens are also encrusted by an epibiont which, in this instance is a bryozoan. Like the Devonian tabulate coral, the bryozoan also is confined

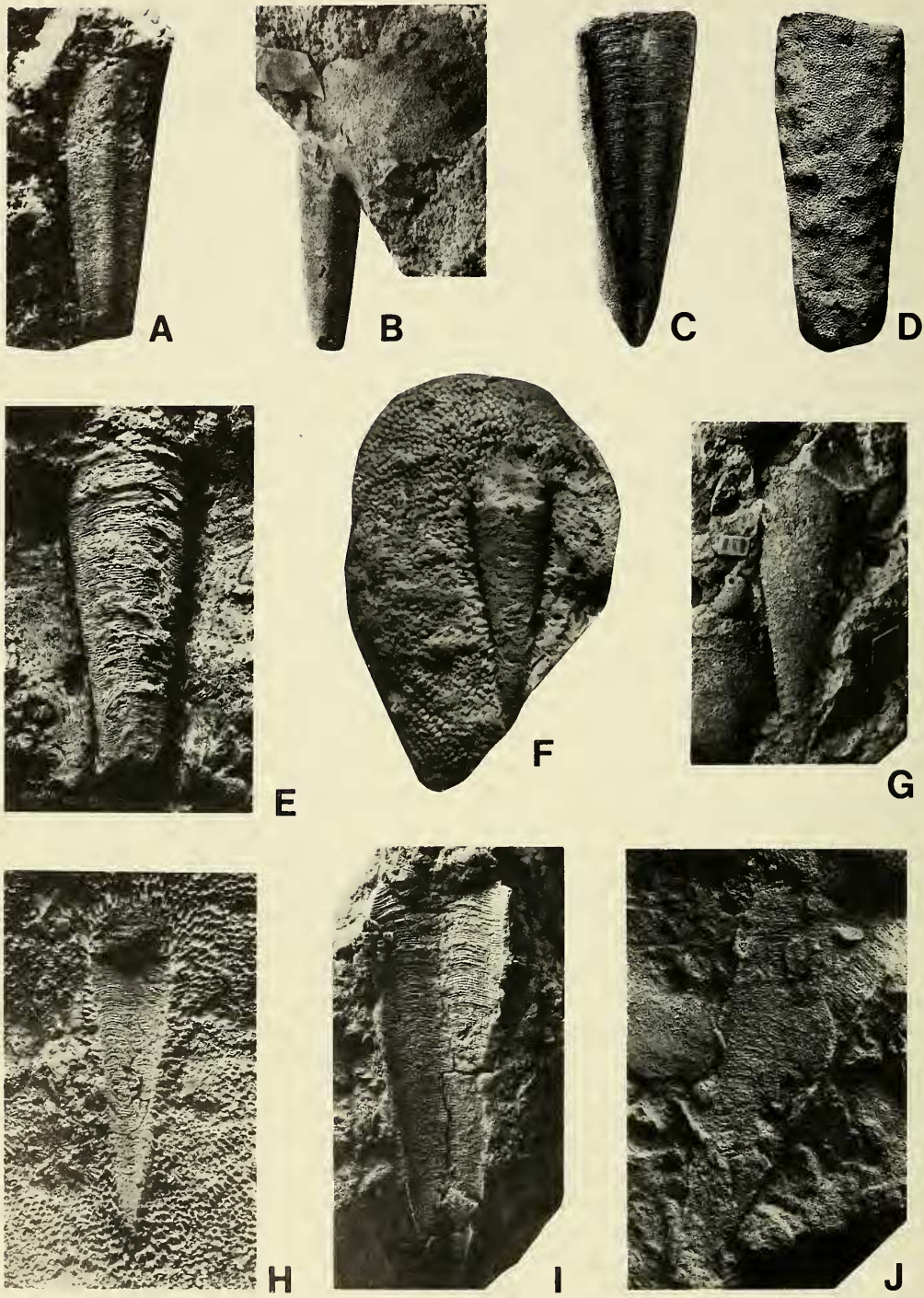

Fig. 1. A, E, *Hyolithes*? *multicinctus* Bradley: A, Paratype FMNH 5916B showing dorsum, ×3. E, Holotype FMNH 5916A showing dorsum, ×1.8, Missouri. B, G, *Solenotheca*? *baconi* (Whitfield): B, Paralectotype UCMP 34360A showing dorsum. G, Lectotype UCMP 35219 showing venter, Wisconsin. Both ×1.1. C, D, External

to the dorsum (Fig. 1C, D, F, H). Had the hyoliths lived with the dorsum down or with the apex imbedded in the sediment, both dorsum and venter would be covered with epibionts.

Repository designations used in this manuscript are: National Museum of Natural History, USNM; Field Museum of Natural History, FMNH; New York State Museum, NYSM; and Museum of Paleontology, University of California, Berkeley, UCMP.

Systematic Paleontology

Phylum Mollusca
Class Hyolitha Marek
Order Hyolithida Matthew
Family Hyolithidae Nicholson

Solenotheca, new genus

Type species.—*Solenotheca bakerae,* new species.

Included species.—*Solenotheca bakerae. Hyolithes baconi* Whitfield (1878), and *H. multicinctus* Bradley (1930) are possible representatives of this genus.

Diagnosis.—Hyolithid which has narrowly rounded dorsum with concavo-convex slopes; ligula short and aperture orthogonal (see Marek 1983a).

Remarks.—Knowledge of *Solenotheca* is derived from six well preserved specimens from the Upper Mississippi Valley region which formerly were listed as hypotypes of *Hyolithes baconi* Whitfield (1878) by an unknown worker. Thirty other specimens from widely scattered localities in the Mississippi Valley region are possible representatives of this genus, but incomplete preservation precludes confident identification of those specimens.

Solenotheca differs from all other genera currently included under the Hyolithidae (see Malinky 1988 for listing of genera in that family) by the presence of concavo-convex slopes on the dorsum. The only other hyoliths to possess a similar feature are members of the Family Similothecidae Malinky (1988) from the Lower Cambrian of Newfoundland. However, the dorsum on similothecid hyoliths terminates in a protruding keel on the longitudinal ridge. *Solenotheca* lacks a keel. Furthermore, *Solenotheca* has a cancellate pattern of ornament created by closely spaced transverse lirae and widely spaced longitudinal lirae; on the similothecid hyoliths the transverse ornament as well as longitudinal ornament is widely spaced. The features which characterize *Solenotheca* have not been reported on any Soviet or Chinese hyolith (Syssoiev 1962, 1968, 1974; Val'kov 1975; Qian 1977, 1978).

Stratigraphic range.—Middle Ordovician.

Etymology.—The name of the genus is derived from the Greek *solen,* meaning furrow, in reference to the concave slopes.

Solenotheca bakerae, new species
Fig. 2E–G

Diagnosis.—*Solenotheca* with widely spaced longitudinal lirae superimposed upon closely spaced transverse lirae and transverse threads which create a cancellate pattern on shell and internal mold.

Description.—Venter slightly inflated with narrowly rounded lateral margins. Dorsum low and narrowly rounded in middle. Adjacent slopes convex next to lateral margins, but are markedly concave elsewhere. Transverse outline of shell subtriangular; sides of triangle concave. Ventral ligula short and straight, broadly rounded anterior edge.

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mold and dorsum of shell, respectively, of unidentifiable hyolith USNM 50107A showing bryozoan encrustation, ×2, Ohio. F, H, Latex cast and external mold, respectively, of unidentifiable hyolith USNM 50102A showing bryozoan encrustation; F, ×4, H, ×4.5, Ohio. I, External mold of unidentifiable hyolith USNM 50107B showing dorsum, ×2, Ohio. J, External mold of unidentifiable hyolith USNM 6833 showing venter(?), ×2, Ohio.

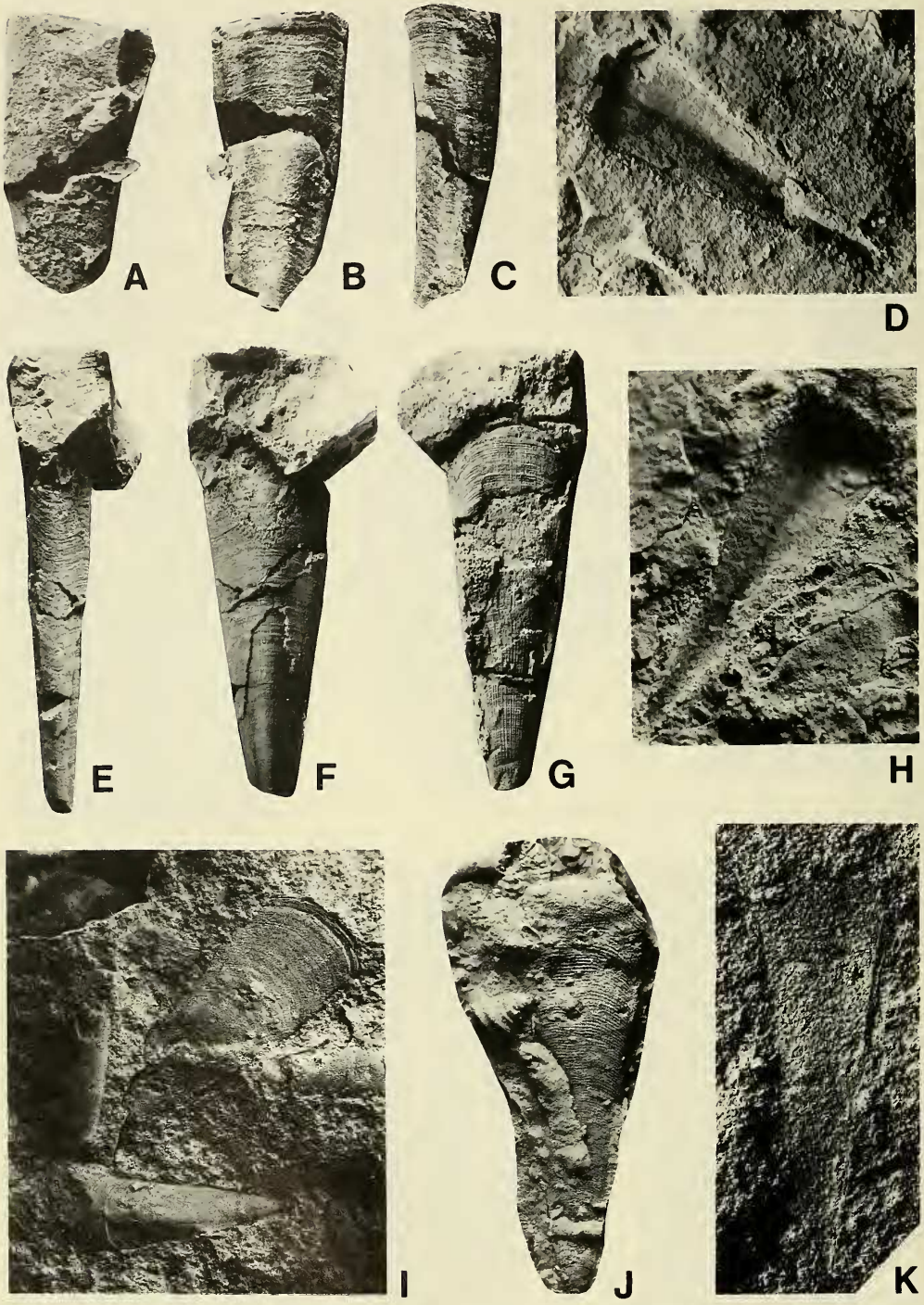

Fig. 2. A–C, *Hyolithes*? *rhine* Ruedemann: venter, dorsum and left lateral view, respectively, of holotype NYSM 3514, original shell, ×2, New York. D, H, *Hyolithes*? *pumilus* Ruedemann: D, paralectotype NYSM 9425B, dorsal(?) external mold, ×5.5, New York. H, lectotype NYSM 9425A, dorsal(?) external mold, ×1.6, New York. E–G, *Solenotheca bakerae* n. gen., n. sp: holotype USNM 50086A, right lateral, dorsal and ventral

Sides of ligula dip steeply away from anterior edge. Apertural rim orthogonal with shallow sinus along aperture on each lateral margin but not on dorsal margin. Apertural rim not flared. Apical end appears straight.

Shell covered with alternation of transverse threads and transverse lirae. Lirae parallel outline of aperture; on dorsum lirae transverse, and curve on lateral margins to follow apertural sinuses. On venter lirae follow edge of ligula. Fine, longitudinal lirae superimposed upon transverse ornament create cancellate pattern on shell. Internal mold also with cancellate pattern of ornament defined by transverse threads and lirae with longitudinal lirae superimposed upon them. Operculum unknown.

Remarks.—The holotype (Fig. 2E–G) is a steinkern covered with scattered fragments of shell; it measures 25.5 mm in length and has an apertural width and height of 9.5 mm and 5.0 mm respectively. Matrix adheres to the apertural end but enough detail is exposed so that the apertural rim can be seen. A small portion of the apical end is broken. Several other specimens are sufficiently well preserved to serve as paratypes. The types of this species were originally designated as hypotypes of *Hyolithes baconi* Whitfield (1878) by an unknown worker, probably because of a general resemblance in conch form between them. However, the types of *H. baconi* lack all details of the aperture and ligula, as well as ornament on the shell. No further comparison between the two species is possible.

Material.—All specimens reposited at USNM. Holotype 50086A and paratypes under 50086B, 50086C, 25269 and 2 paratypes under 25270. Specimens questionably referred to *Solenotheca* species indeterminate, are catalogued as follows: 11 under 15764A and 2 under 15764B; 11 under 50088; 1 under 25272, 4 under 50087A and 1 under 50087B.

Occurrence.—Geographic and stratigraphic information for all specimens is scant. Knowledge of occurrences is derived entirely from labels associated with the specimens. The holotype and paratypes 50086B and 50086C are from "Minneapolis, Minnesota." Paratype 25269 is from "5 m. n. Monroe, Green Co., Wis." This presumably means 5 miles north of Monroe. Paratypes 25270 are from "Black River (Platteville), Belleville, Wisconsin." The 11 specimens catalogued as 15764A, the 2 under 15764B and those under 50088 are all from "Beloit, Wis."; specimen 25272 is from "Platteville, Wisconsin"; specimens 50087A and 50087B are in a container labelled "Cannon Falls, Minnesota" but labels enclosed with the specimens say "chiefly from beneath sponge bed Platteville-Upper Dixon, Illinois." Labels with those specimens indicate that they were collected by E. O. Ulrich and R. S. Bassler in 1906, although there is no indication as to which locality is correct (Fig. 3).

Webers & Austin (1972) recognized five Middle Ordovician formations which encompass several hundred meters of carbonate rock in the Upper Mississippi valley region. The Platteville, Decorah and Galena formations contain layers of limestone or dolostone as well as other lithologies. In the absence of any detailed data on localities or associated faunas, confident assignment of any of the specimens cited above to formation is impossible at this time. The age of strata in these areas is Middle Ordovician (Webers & Austin 1972).

Stratigraphic range.—Middle Ordovician.

Etymology.—The species is named for Cathy Baker, Simpson College.

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views, respectively, original shell, ×2.8, Minnesota. I, Slab under USNM 78431A showing venters of unidentifiable Ordovician hyoliths, ×2, Missouri. J, Unidentifiable Ordovician hyolith, USNM 50087B, venter, ×2, Ohio. K, *Hyolithes*? *pinniformis* Ruedemann. Holotype(?) NYSM 9423, venter(?), ×5.3, New York.

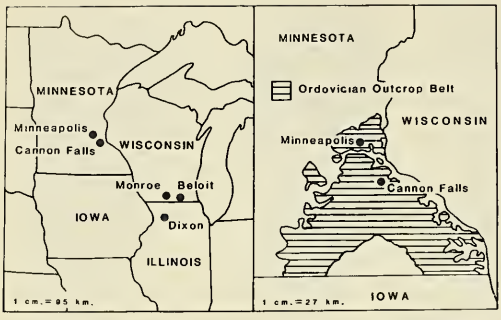

Fig. 3. Generalized locality map for holotype and paratypes of *Solenotheca bakerae* n. gen., n. sp.

Class Hyolitha incertae sedis
Solenotheca? *baconi* (Whitfield, 1878)
Fig. 1B, G

Hyolithes baconi Whitfield, 1878:77; 1882: 225, pl. 6, figs. 9–11.—Sinclair, 1946:74.

Description.—Venter flat toward middle but becomes slightly inflated toward narrowly rounded lateral margins. Dorsum low and narrowly rounded in center; adjacent slopes appear nearly flat to slightly concave. Ligula appears long and straight. Apical single small and apical end straight. Complete dorsum, aperture, shell and operculum unknown.

Remarks.—Type material of this species consists of dolomitized steinkerns from which all details except the proportions of the conch have been obscured by diagenesis. All specimens are embedded in matrix, from which extraction intact would probably be impossible. Specimen UCMP 32519 (Fig. 1G) is here designated the lectotype; it measures 34.0 mm in length and is 11.0 mm wide near the apertural end. The paralectotypes (Fig. 1B) are comparable to the lectotype in size.

This species was named and described but not illustrated by Whitfield (1878). His initial description was repeated nearly verbatim slightly later (Whitfield 1882) and was accompanied by drawings (pl. 6, figs. 9–11). The drawings show this species to have two longitudinal sulci on the dorsum and transverse lirae on both dorsum and venter. The drawings also depict a short ligula with a broad anterior edge, and a low dorsum. No specimens in the type lot match these illustrations; there is no evidence for the sulci or lirae shown. The drawings are apparently reconstructions of how Whitfield thought complete, well preserved specimens of this species should appear. The gently concave dorsal slopes suggest affinity to *Solenotheca,* to which this species is referred with question.

Material.—Lectotype UCMP 32519 with paralectotypes on specimens under UCMP 34360-A and UCMP 34360-B.

Occurrence.—According to Whitfield (1878:77), these specimens were discovered "in the hard bluish layers of the Trenton group, below Carpenter's quarry, near Beloit, Wisconsin." Beloit is located in southern Rock County near the border of Illinois and Wisconsin. The age of the species is Middle Ordovician.

Solenotheca? *multicincta* (Bradley, 1930)
Fig. 1A, E

Hyolithes multicinctus Bradley, 1930:240, pl. 25, fig. 13.—Sinclair, 1946:78.

Description.—Conch with small apical angle and apical end appears straight. Dorsum low and narrowly rounded; slopes on dorsum appear slightly concave. Lateral margins narrowly rounded and dorsal apertural rim appears orthogonal. Shell covered with closely spaced transverse lirae; lirae curve slightly in middle of dorsum to create shallow sinus but are transverse elsewhere. Dorsum covered with fine, closely spaced longitudinal lirae; on lateral margins lirae also curved to create shallow sinus. Venter, complete apertural end and operculum unknown.

Remarks.—Knowledge of this species is derived from the holotype (Fig. 1E) and a specimen included in this species as a paratype (Fig. 1A). The holotype measures 26.0 mm in length, and has an apertural width

of 9.6 mm; the paratype is comparable in size. Both specimens retain the original shell, but each is embedded partly in matrix so that only the dorsum is exposed. Any attempt to extract these specimens from the matrix would probably destroy them.

Bradley (1930) noted comparison between this species and *H. baconi* Whitfield (1878), but he seems to have compared his specimens to Whitfield's illustrations rather than to Whitfield's specimens. No comparison between the types of these species is possible because of preservation. Bradley (1930) also reported minor differences of ornament between *H. multicinctus* and *H. miseneri* (Foerste, 1917) as a basis for separating these species. Foerste (1917) stated that *H. miseneri* has a cancellate pattern on the dorsum formed by the intersection of transverse and longitudinal lirae, whereas Bradley (1930) stated that all lirae on *H. multicinctus* are transverse. Bradley (1930) was mistaken on that point, for a reexamination of the types of *H. multicinctus* demonstrates that fine longitudinal lirae occur on the dorsum of those specimens, suggesting that both forms may belong to the same species. Concave slopes on the dorsum of *H. multicinctus* suggest placement under *Solenotheca,* to which this species is now assigned with question. Assignment to genus for *H. miseneri* (Foerste, 1917) awaits further study of that specimen.

Material.—Holotype FMNH 5916A and paratype FMNH 5916B.

Occurrence.—Bradley (1930:241) cited the occurrence as "Kimmswick limestone near Glen Park, Missouri." The age of the species is Middle Ordovician.

Hyolithes? *pinniformis* Ruedemann, 1912
Fig. 2K

Hyolithes pinniformis Ruedemann, 1912: 111, pl. 7, figs. 12, 13.—Sinclair, 1946: 79.

Description.—Conch with subtriangular outline; apical angle appears small and apical end appears straight. The shell, and all other details of conch, and operculum, unknown.

Remarks.—The holotype (Fig. 2K) is the only known specimen of this species. It consists of a subtriangular impression on a bedding surface in black shale. That specimen measures 11.3 mm in length, and has a maximum width near the apertural end of 3.2 mm. Preservation of this specimen is extremely poor; even the most elementary morphologic features, such as the ligula or any distinguishing features of dorsum and venter are lacking. Ruedemann's (1912) drawings of this species (pl. 7, figs. 11, 12) depict a shell with a complete aperture and lirae on the exterior. They bear no resemblance to the specimen described and illustrated herein. Perhaps the drawings are reconstructions of how Ruedemann thought complete specimens of this species should appear, or perhaps the illustrated specimen is lost. This species cannot be properly diagnosed using only the specimen described herein.

Material.—Holotype(?) NYSM 9423.

Occurrence.—Ruedemann (1912:111) cited the occurrence as: "Canajaharie shale at Canajaharie, N. Y." Canajaharie is located in Montgomery County in central New York. The age of the species is Middle Ordovician.

Hyolithes? *pumilus* Ruedemann, 1926
Fig. 2D, H

Hyolithes pumilus Ruedemann, 1926:77, pl. 10, figs. 5, 6.—Sinclair, 1946:79.

Description.—Dorsum inflated and narrowly rounded in center; lateral margins narrowly rounded. Apical angle small and apical end appears straight. Complete apertural end, shell, venter and operculum unknown.

Remarks.—This species is represented by two poorly preserved external molds on a slab of dark gray shale that also contains ostracods and a "syntype" of *Rafinesquina*

alternata centristriata Ruedemann. Specimen NYSM 9425A (Fig. 2H) is here designated the lectotype; it measures 9.3 mm in length and has an apertural width of 4.0 mm. The paralectotype (NYSM 9425B) (Fig. 2D) is similar in size and preservation to the lectotype. Both specimens are smooth and featureless, and neither retains a shell or an operculum.

Ruedemann (1926, pl. 77, figs. 5, 6) illustrated specimens of this species that he refers to as the holotype (fig. 5) and paratype (fig. 6). In one drawing, the holotype possesses a short ligula which is broadly rounded at the anterior edge, and it appears to have a longitudinal sulcus near the middle of the dorsum. Another drawing depicts a paratype that is less well preserved and lacks the ligula and sulcus. None of the existing specimens match Ruedemann's illustrations. Either his drawings are reconstructions of how he thought well preserved specimens of this species should appear, or the illustrated specimens are lost.

Material.—Lectotype NYSM 9425A and paralectotype NYSM 9425B.

Occurrence.—Ruedemann (1926:78) reported that the slab of shale containing both specimens was discovered in "zone I of the lower Lorraine (Whetstone Gulf) shale, in the Whetstone and Lorraine gulfs." The age of the species is Late Ordovician.

Hyolithes rhine Ruedemann, 1901
Fig. 2A–C

Hyolithes rhine Ruedemann, 1901:36, pl. 2, figs. 12–15.—Sinclair, 1946:79.

Description.—Venter slightly inflated with narrowly rounded lateral margins. Dorsum inflated and narrowly rounded in center; slopes on dorsum slightly inflated. Apical end appears straight, and apical angle small. Faint longitudinal sulcus near each edge of the dorsum; sulcus extends along entire length of dorsum but becomes shallow near apical end. Shell covered with faint transverse lirae on dorsum. Lirae curve slightly in middle of dorsum to form shallow sinus; apertural rim may be orthogonal. Internal mold of venter smooth. Complete apertural end and operculum unknown.

Remarks.—The holotype (Fig. 2A–C) is the only known specimen of this species. It measures 21.0 mm in length, and has an apertural width and height of 10.2 mm and 6.2 mm respectively. The shell is preserved locally on the dorsum, but is absent on the venter. The holotype was broken out of limestone, and an impression of the outer surface of the shell remains in the matrix as a counterpart of the holotype. The counterpart is an impression of the dorsum rather than the venter as Ruedemann (1901) believed.

The dorsal lirae of *H. rhine* resemble those of *H. multicinctus* Bradley (1930), but the lirae on *H. rhine* are less conspicuous. Ruedemann (1901) compared this species to drawings of *H. baconi* Whitfield and *H. multicinctus* Bradley, but detailed comparison between these species is precluded by the absence of important taxonomic features on each.

Hyolithes rhine possesses longitudinal sulci on the dorsum, a feature shared with only three other hyolith species: *Hyolithes acutus* Eichwald (1840), the type species of that genus, from the Ordovician of Estonia, *H. crebescens* Resser & Endo (1937) from the Middle Cambrian of China, and *Hallotheca aclis* (Hall, 1876) from the Devonian of New York. Nonetheless, various other features of the conch of each form suggest that each form probably represents a different species.

Material.—Holotype NYSM 3514.

Occurrence.—Ruedemann (1901) did not cite a specific occurrence for this species, but he named it in a study of the fauna of the Trenton conglomerate at Rysedorph Hill, Rensselaer County, New York. The introduction of the work includes generalized information about a number of localities on Rysedorph Hill, and several outcrops are marked with arrows in a photograph of the hill. The specific outcrop which yielded the type of this species is not

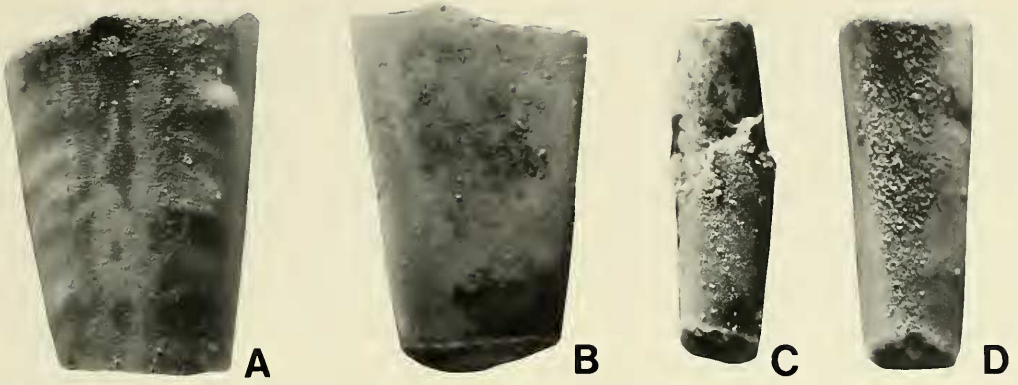

Fig. 4. A, B, D, *Hyolithes*? *versaillensis* Miller & Faber: dorsal, ventral and right lateral views, respectively, of lectotype FMNH 8876A, ×17, Indiana. C, specimen FMNH 8881 formerly assigned to *Hyolithes*? *dubia* Miller & Faber, lateral view, ×12, Indiana.

indicated. The age of the species is Middle Ordovician.

Hyolithes? *versaillensis*
Miller & Faber, 1894
Fig. 4A, B, D

Hyolithes versaillensis Miller & Faber, 1894: 15; pl. 8, figs. 20–22.—Cummings, 1908: 965, pl. 42, figs. 4, 4a.—Sinclair, 1946: 81.

Description.—Venter flat to slightly inflated, with narrowly rounded lateral margins. Dorsum inflated and broadly rounded, and transverse shape subtriangular. Apical end appears straight, and apical angle small. Several widely spaced ribs on internal mold of dorsum; internal mold of venter smooth. Complete aperture, shell, and operculum unknown.

Remarks.—Type material of this species consists of eight specimens; specimen FMNH 8876-A (Fig. 4A, B, D) is here designated the lectotype. That specimen measures 2.9 mm in length, and has an apertural width and height of 2.2 mm and 1.3 mm respectively. All paralectotypes are comparable to the lectotype in size. Every specimen of this species is a partially weathered limonitized steinkern. No specimen is complete and none is operculate.

Miller & Faber (1894) thought that these specimens were casts rather than internal molds, and based their species diagnosis on the supposed "smoothness" of the shell. They also noted that "there are not many characters to ascribe to this species" (p. 155) and as a result, their description is generalized and lacks detail. The diagnosis of this species and the illustrations (pl. 8, figs. 20–22) are inadequate to characterize this species because few features are preserved.

Material.—Lectotype FMNH 8876A and seven paralectotypes under 8876B.

Occurrence.—Miller & Faber (1894:155) reported that this species "is quite common in the upper part of the Hudson River Group, at Versailles, Indiana, associated with *Palaeoconcha faberi, Cyclora pulcella* and other small fossils." Versailles is located in Ripley County in southeastern Indiana. The age of the Hudson River group is Late Ordovician.

Class Trilobita incerate sedis
Genus and species indeterminate
Fig. 4C

Hyolithes? *dubius* Miller & Faber, 1894:155, pl. 8, fig. 23.—Cummings, 1908:964, pl. 42, fig. 3.—Sinclair, 1946:75.

Description.—"Conch" tubular and apical angle small. Taper of conch so slight that both ends appear of equal diameter. Shell

and internal mold smooth; both ends unknown.

Remarks.—The holotype (Fig. 4C) and only specimen of this species measures 4.2 mm in length with a diameter of 1.0 mm. The original skeletal material is largely intact, although at the narrower end a small section of the internal mold is exposed. The specimen is broken at both ends, and no other features than those cited above are preserved.

Miller & Faber (1894) did not recognize that the original skeletal material is preserved on this specimen, for they cited the specimen as being a "cast." They were apparently uncertain about the affinity of this species, and assigned it to *Hyolithes* with question. They suspected affinity to calymenid trilobites which occur in the same strata as this species. However, because all the trilobite fossils of which they were aware were intact, they ruled out the possibility that the type of *H.? dubius* might be a fragment of a trilobite spine. They noted that this species is "like *Hyolithes versaillensis,* with which it is associated, and it would seem, therefore, impossible that it (*H.? dubius*) should represent the broken spines of trilobites" (p. 156). The two species are quite dissimilar in terms of both morphology and preservation. *H.? dubius* lacks any evidence for hyolith affinity such as a shell with transverse growth lirae or an operculum. It is without question the spine of a trilobite.

Material.—Holotype FMNH 8881.

Occurrence.—Miller & Faber (1894:156) cited the occurrence as "the upper part of the Hudson River Group, at Versailles, Indiana, associated with *Palaeoconcha faberi, Cyclora pulcella, Hyolithes versaillensis,* and other small fossils." The age is Late Ordovician.

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